6 Past, Present, and the Future of Canal Irrigation in India

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Introduction

At the beginning of the eighteenth century, India was the 'irrigation champion' of the world. While the colonial government initially neglected the maintenance and upkeep of the numerous but mostly small irrigation structures, it soon spotted the potential for large-scale canal irrigation as an economic enterprise and took to canal building as a business on a massive scale. In those days, there was much dissatisfaction with irrigation management among observers and investors who expected much higher financial return on irrigation investments. Yet, in retrospect, around AD 1900, canal irrigation systems in India were arguably in a far better state than today in terms of their operation and maintenance (O&M), productivity impacts, and financial returns. If we look at the situation ten years ago, around 2000, while the new welfare state had kept alive the colonial tradition of big time canal construction, the management of canal irrigation had become pathetic in terms of all the criteria on which it excelled a century ago. The dominant view about the way out is that farmer management through water user associations can restore canal irrigation to its old glory. However, this may not be the correct thinking. This chapter argues that the larger socio-technical fundamentals in which canal irrigation can thrive in a smallholder agrarian setting were all mostly present around 1900 and are all mostly absent today. The motives for irrigation building have changed, as has the politics around it as well as the nature of the Indian state and society. Most of all, the veritable and pervasive groundwater boom in Indian agriculture during recent decades raises questions about the relevance of traditional canal irrigation for Indian farmers who want on-demand irrigation, all round the year. Canal irrigation policy can chart several alternate courses in the future, of which four are explored in this chapter: (i) continue in a business-as-usual mode, keep throwing good money after bad, and decline into irrelevance; (ii) maximize the areal extent of conjunctive use of surface and groundwater by truly functioning as extensive irrigation systems as they were originally designed; (iii) reform the irrigation bureaucracies for greater professionalism, accountability, and performance orientation; (iv) reconfigure public irrigation systems as hybrid systems in which the irrigation departments are responsible for reliable bulk water deliveries and private irrigation service providers (ISPs) retail the water to irrigators. Some of (iii) and (iv) is already happening, but by sheer default, rather than by design. Public irrigation can serve the country far better if a considered strategy of reinventing the role of reservoirs and canal distribution is pursued in today's changed context. For this to happen, the first step is to establish a credible information and monitoring system to assess public irrigation performance against its design and current objectives.

Canal Irrigation in India *c.* 1900

Gravity flow irrigation is central to Indian social history. According to Alfred Deakin (*The Age*, 1891), during the late 1900s, the region had 12 million hectares (ha) of irrigated land compared with 3 million ha in the United States, 2 million ha in Egypt, 1.5 million ha in Italy, and a few hundred thousand ha each in Ceylon, France, Spain, and Victoria (Australia). Canal irrigation experienced its most rapid expansion in India during the last years of the nineteenth century.

In its big-time irrigation construction, the British irrigation enterprise revived, rehabilitated, and built upon the irrigation canals that lay in disrepair during the early decades of the Company rule. Colonial investment in canal irrigation consistently yielded 8–10 per cent return on investment right until 1945 (Whitcombe 2005). Whitcombe estimated that between 1912–13 and 1945–6, irrigation investments of the Government of British India returned a net profit, increasing from 8.3 per cent on productive works and 4.5 per cent on all major works in 1912–13 to 12.8 per cent on productive works and 7.2 per cent on all major works in 1945–6. This calculation, based only on water charges collected, did not include the higher revenue assessment on irrigated land.

The key was intensive revenue management through an elaborate but low-cost irrigation administration appropriate for large irrigation systems but useless for myriad small, community-based water harvesting and irrigation structures. For government schemes, to collect irrigation fees and manage water distribution at the village level and above, the colonial government maintained a large irrigation bureaucracy. Even with an elaborate administrative apparatus, wherever possible, the government outsourced water distribution to large land holders who received water from public systems in their private distribution canals. Private canals were a substantial source of irrigation in the irrigated area in colonial north-western India. In 1943–4, nearly 500,000 acres in British Punjab were irrigated by private canals captive to one or a few farmers. In Shahpur district, where the government encouraged construction of private canals, all the canals were owned by just two families, Noon and Tiwana (Islam 1997: 36). Apart from these super-sized farm holdings, even ordinary irrigators had much larger holdings of 50 to 540 acres (Ibid.: 83). These relatively large landholdings made irrigation management below the outlet easier than it is today.

The colonial irrigation management was thus a high-input-high-output affair. A vast authoritarian bureaucracy reaching down to the village level used forced labour to maintain canal network, managed water distribution, and undertook ruthless water fee recovery on all lands *deemed* to be irrigated. In the canal commands, the canal water 'tax had to be paid regardless of whether or not use was made of the canal in a particular year or whether or not there was a reliable supply from the canal' (Hardiman 2002: 114). This, according to Hardiman, encouraged, even forced, farmers to grow valuable commercial crops to generate cash. It also resulted in much litigation from dissatisfied *zamindars* who put pressure on canal managers to ensure water delivery and maintain canals. The amounts provided for O&M were substantial so that deferred maintenance was minimal.

A hundred years later, the finances of canal irrigation in post-colonial India stood in stark contrast as summarized in Table 6.1. Around 2006, India's Central Water Commission (CWC) reported that the water fee realized by all major and medium irrigation projects was all of 8.8 per cent of the 'working expenses' during 1993–7 and the ratio had declined further to 6.2 per cent during 1998–2002 (CWC 2006) compared to 2.5 to 3 times of water expenses around 1900. During 1961–2001, the capital outlay on major and medium irrigation schemes at 2000 prices was approximately Rs 295,000 crore (Amarasinghe and Xenarios 2009). In 2005, the World Bank estimated that some Rs 19,000 crores should be provided for maintenance of irrigation infrastructure but only Rs 2820 crore (0.1 per cent of capital cost) was spent on maintaining these public irrigation assets; water fee recovered from irrigators was all of Rs 652 crore, less than 10 per cent of the 'working expenses' of Rs 8250 crore (CWC 2006: Table A1).

As a commercial venture, the performance of canal irrigation has decidedly declined over the past 100 years. D.R. Gadgil, the pioneer of Indian economic planning, had argued that, in a poor agrarian economy like India, public irrigation investments should be judged on their social and economic returns rather than their financial returns. As if on cue, soon after Independence, irrigation charges were drastically reduced; and even these

TABLE 6.1 Deteriorating Finances of Indian Canal Irrigation, AD 1900 compared with AD 2000

		Major and medium systems in British India, 1902–3	*Major, medium, and multi-purpose irrigation Projects in India 1977–8*	*1986–7*	*Major and medium irrigation systems in India, 2001*
1	Capital investment in major and medium projects (nominal)	£ 30 million	Rs 3004 crore	Rs 26014 crore†	Rs 295,000 crore
2	Area irrigated by all government schemes (m ha)	7.4	18.75	25.33‡	18
3	Water fees collected as per cent of capital investment	10 per cent	1.43 per cent	0.3#	0.2 per cent
4	Value of crops irrigated as per cent of capital investment	87 per cent	na	Na	18.3 per cent*
5	Water fees collected as per cent of value of crops irrigated	11 per cent	Na	2 per centΨ	1.2 per cent
6	Water fee collected as per cent of Working Expenses	280 per cent	45 per cent	20 per centΩ	7.9 per cent
7	Maintenance expenditure as per cent of working expenditure	53 per cent	42 per cent	38 per cent	34 per cent
8	Maintenance expenditure as per cent of capital investment	2.6 per cent	na	Na	0.95 per cent

Source: Data for 1902–3 from Buckley (1905); for 1977–8 and 1986–7 from Government of India [GoI] (1992); for 2001 from CWG (2006).

Notes: † GoI (1992: Annexure 1.5).This includes around 215 BCM of reservoir storage, and around 80 BCM in run-off the river system plus thousands of large irrigation tanks and *ahar-pyne* systems.

‡ GoI (1992: Annexure 1.7-A).

Computed using irrigation charges collected (as in GoI 1992: Table 2.6) as percentage of capital investment (in row 3).

* Assuming 18 million ha of canal irrigated area growing crops worth Rs 30,000/ha at 2000–1 prices.

Ψ GoI (1992: 2.25). 'The Irrigation Commission had suggested that water rates should be fixed at around 5 per cent of gross income for food crops and 12 per cent for cash crops. At present, the actual gross receipts per ha of area irrigated by major and medium projects is barely 2 per cent of the estimated gross output per ha of irrigated area, and less than 4 per cent of the difference between output per ha of irrigated and unirrigated areas.'

Ω Computed from GoI (1992: Table 2.6).

remained increasingly uncollected. Around 1930, irrigation fees were the largest source of government revenue in Punjab, higher than even income tax (Islam 1997); but these declined rapidly after 1950. By 1960, the scenario throughout the country had changed drastically for the worse. In a study of Bihar, Bhatia (1991) showed that irrigation dues in 1960 were so small that it made eminent sense to relocate the 5000-strong force deployed in collection elsewhere and abolish the irrigation fees altogether. This trend continued in other states where irrigation fees remained stagnant for decades; and the proportion of total demand actually collected declined to a small fraction. Have public irrigation investments in free India delivered the irrigation—and the socio-economic returns—they were designed for as Gadgil had hoped?

Unfortunately, the answer to the question is 'No'; and there lies the heart of the problem. The financial rot was the harbinger of a much deeper crisis of stagnation and decline in public irrigation systems whose social and economic returns turned out to be far smaller than imagined. In one of the earliest reviews in the mid-1980s, Daines and Pawar (1987: 2) noted that 'most investments in existing large public surface irrigation systems have had rather low economic rates of return in the range of 4–12 per cent'. Many factors explain this decline, but four are the most important: first, all-round deterioration in planning and management of public irrigation at all levels; second, failure to anticipate and adapt to the rising tide of pump irrigation from surface and groundwater, within and outside the command areas; third, the resultant reorganization of India's irrigation economy; and fourth, the challenge of performance management of public irrigation systems in the new irrigation economy.

Decline in Public Irrigation Management Performance

Researchers writing during the 1980s noted that surface irrigation systems tended to always be perennially underutilized, and typically only a fraction of the designed command was actually irrigated soon after the completion (Daines and Pawar 1987). The key problem, many observers noted, was poor maintenance and system management, especially below the outlet. Repetto (1986: 4) foresaw the problem when he wrote that 'public irrigation systems themselves are sinking under their managerial, economic and environmental problems.' And David Seckler, another keen observer of the Indian irrigation scene, wrote: 'As the rug of irrigation development is rolled out ahead through construction of new facilities, it will roll up behind through poor maintenance and management of existing facilities' (cited in Wade 1984: 286). Without understanding the larger malaise, donors pumped in large volumes of funds in the name of 'rehabilitation and modernization' which led to throwing good money after bad. The colonial irrigation's ethos of 'build–manage–generate surpluses–maintain' gave way to a 'build–neglect–rebuild' syndrome.

The reality of an Indian irrigation system is that it never seems to conform to its design. Most were overdesigned to pass the cost–benefit test; and once constructed, anarchy followed in the command areas. Everywhere, the central problem is 'unauthorized' over-appropriation of water by head-reach farmers for growing crops that irrigation planners had never expected them to grow. Most Indian irrigation systems were mostly designed for protective irrigation over large areas; moreover, they assumed 'that farmers will stick to subsistence production of food crops, when supplementary irrigation is made available to them' (Jurriens et al. 1996). But reality never conformed to this plan. Systems designed for irrigated dry crops—as in Karnataka's Tungbhadra canal—collapsed into rice irrigation systems. As a result, the original goal of providing protective irrigation over large areas was defeated (Mollinga 2003). In the north-western systems, as in Haryana, researchers found the much-celebrated *warabandi* (rotational water supply) system—designed to minimize head–tail inequity—eroded beyond redemption; the same has been found for the Indus system in Pakistan (Jurriens et al. 1996; van Halsema 2002) and elsewhere in monsoon Asia where it has been tried (Rice 1996). There are still some regions in India, where such a system is still operational but it is increasingly being threatened. Under the *warabandi,* every farmer is supposed to get equal number of water turns, for equal time, per unit of land. Shah (2003) found high levels of flow irrigation deprivation at the tail-ends during monsoon as well as winter seasons in *warabandi* areas (Table 6.2).[1] As a result, the periphery of the design command increasingly began to rely on groundwater for irrigation.

A number of studies based on micro-level data indicate that decline in the performance of the irrigation administration, strong construction orientation and low O&M orientation of the irrigation bureaucracy, political influence on design and management, institutional vacuum below the minor canals have contributed to the decline in canal irrigation. Even more important than these is the emergence of a vast pump irrigation economy in which scavenging water from any proximate source—ground or surface—has taken precedence over orderly gravity flow irrigation.

Rise of the Water Scavenging Irrigation Economy

When canal irrigation first started in the Indo-Gangetic basin, a large number of wells fell into disuse. Dhawan

[1] The Haryana study defined flow irrigation deprivation as 50 per cent or less of canal irrigation received by the best-off farmer in a watercourse.

TABLE 6.2 Extent of Irrigation Deprivation Levels of Tail-enders in Selected Gravity Flow Irrigation Projects in India

States	*Names and type of systems studied*	*Extent of flow irrigation deprivation (FID) (per cent)*
Gujarat	Dharoi-Major; Mahi Right Bank-Major;	7–37
Haryana	Western Yamuna-Major; Bhakra-Major	56–84
Karnataka	Tungabhadra system-Major; Vanivilas, Medium; Two tanks-Minor	40–91
Maharashtra	Mula-Major; Walen tank-Minor	29–70
Orissa	Hirakud-Major	35–72
Tamilnadu	Parambikulam Aliyar-Major; Two rainfed tanks-Minor	24–55

Source: Shah (2003).

(1996: 537) called this the 'substitutional effect' of public irrigation works which caused amongst farmers, well-placed in new command areas, a 'disinclination even to maintain their own sources of irrigation of pre-canal vintage, not to mention that they drastically cut back on new investments in such means of irrigation'.

However, today, pump irrigation from groundwater wells as well as directly from canals is rampant in Indian systems, leaving surface irrigation systems reconfigured and their command areas redrawn. Where gravity flow once crowded out wells, the opposite is the case today; proliferation of irrigation wells in many canal commands has turned what were irrigation canals into recharge canals. In the course of a field visit to the *Guhai* irrigation system in North Gujarat, we found that most farmers irrigate 35–45 times in a year, but the canal releases are available only 3–4 times. The Guhai system meets only a small fraction of the direct irrigation demand; yet it is highly valued by command area farmers because it contributes more recharge than the rainfall (Shah 2010). Flow irrigation from tanks, used for centuries to grow rice, especially in southern India, is rapidly shrinking with the growing profusion of wells in tank commands. According to Selvarajan (2002), Andhra Pradesh, Tamil Nadu, Karnataka, and Orissa, which together accounted for 60 per cent of India's tank-irrigated area, lost about 37 per cent of the tank-irrigated area from 1965 to 2000.

Wells replacing tanks and *ahar-pyne* structures was understandable. But during the 1990s, they began to do the same to major and medium canal irrigation systems. In the Bhakra command in North-west India, canal irrigation at first drove out wells. However, since the 1990s, the trend has been reversed (Dharmadhikari 2005), and now, 75 per cent of all irrigated areas in Indian Punjab depend upon well and tube well irrigation (Singh 2006, citing a Government of Punjab 2005 document). This is happening at the national scale too (Selvarajan 2002; Thakkar 1999: 19). Comparing land-use statistics for India, Janakarajan and Moench (2006) noted that between 1996–7 and 2002–3, the area under canal irrigation declined by 2.4 million ha (13.8 per cent), the area under tank irrigation fell by 1.4 million ha (42.4 per cent), and the area irrigated by all other sources declined by 1 million ha (28 per cent). The only irrigation source that increased its share was groundwater wells, by 2.8 million ha (more than 9 per cent). Comparing the minor irrigation census data for 1993–4 and for 2000–1 suggests that in the seven intervening years in those states common to both the censuses,[2] surface irrigation systems lost 4.6 million ha (29.4 per cent) from their command, roughly at the rate of 0.65 million ha per year. Groundwater-irrigated areas grew during the same period by 4.35 million ha.

To reverse the deceleration in canal irrigated areas, the Government of India instituted the Accelerated Irrigation Benefits Programme to step up the investment in the last-mile projects. More than US$ 7.5 billion has been invested in these projects since 1997.

[2] Andhra Pradesh, Arunachal, Bihar and Jharkhand, Goa, Himachal Pradesh, Madhya Pradesh and Chhattisgarh, Orissa, Punjab, Rajasthan, Uttar Pradesh and Uttaranchal, West Bengal, Gujarat, and Maharashtra.

However, instead of acceleration, public irrigation command areas have continued to decelerate during this period. A recent study of 210 major and medium irrigation projects by a Delhi NGO used data from the Ministry of Agriculture to show that after investing Rs 130,000 crore, these projects delivered 2.4 million ha less irrigation during 1990–01 to 2006–7. Similar results were obtained by comparing the data from three minor irrigation censuses. The public irrigation policy seems unhelpful as governments have to invest twice as fast in canal irrigation projects every year just to keep their command areas from shrinking, as Figure 6.1 suggests.

Changing Organization of India's Irrigation Economy

All this suggests that India's irrigation economy is in the throes of a massive transformation; and public irrigation systems are losing their position of dominance in this changing playing field. Wallach, writing about the Nagarjunsagar project in Andhra Pradesh during the 1980s spoke of the Indian reality that 'dams and canals are splendid monuments, but as water distribution systems they are rarely able to deliver water to more than half of their commands'.[3]

In contrast, the pump irrigation economy is spreading faster than previously imagined, especially since 1990. Fifty years ago, rural India had a clear water-divide: most irrigated area was concentrated within canal commands and there was little irrigation outside. But that is not so any longer. An all-India National Sample Survey (NSS) survey of 78,990 farm households in 1998 showed hardly any difference in the average gross area irrigated per sample household in villages with government canals (1.8 ha) and those without government canals (1.69 ha). It found: 'a marked rise in privately owned irrigation facilities … (and that a) large part of the cultivated land today is irrigated by hiring pumpsets' (National Sample Survey Organization, NSSO 1999: 39). A 2002–3 survey of 51,770 farm households from 6638 villages around India showed that 69 per cent of the sample area irrigated

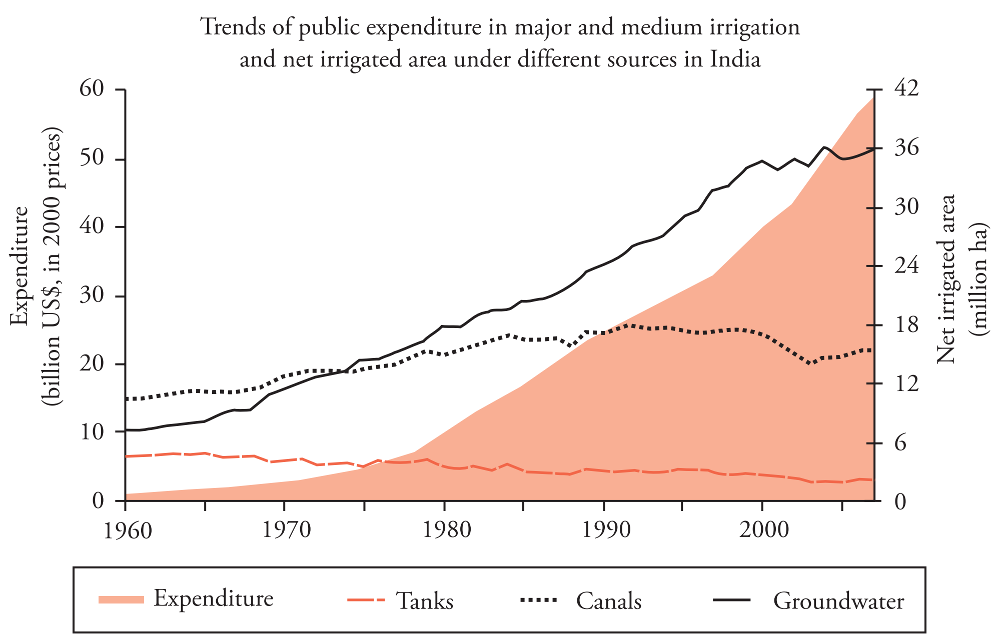

Figure 6.1 Accelerating Investment and Decelerating Irrigation Benefits

Source: IWMI (2009).

[3] http://ags.ou.edu/~bwallach/documents/Krishna%20Basin.pdf last accessed on 30 October 2009.

in *kharif* and 76.5 per cent in *rabi* was served by wells and tube wells (NSSO 2005). Yet another large-scale NSSO (2003) survey found that in 2002, 76 per cent of the 4646 villages surveyed had irrigation facilities, but mostly in the form of tube wells. Of villages that reported having irrigation facilities, 76.2 per cent were irrigated by tube wells. The CWC claims that over 30 million ha are irrigated by canals. All other sources suggest that this figure is around 15 million ha; and that the pump irrigation economy reaches supplemental irrigation to an undetermined area anywhere between 30 and 90 million ha, depending upon the data source (see Table 6.3).

Parameters for Performance Management

Finally, a major driver of the declining performance of public irrigation projects is the difficulty in assessing their performance. During colonial times, when water rates were high and vigorously collected, total irrigation fee collection and financial returns offered a robust surrogate of performance. But today, irrigation fee collection tells us nothing about the performance of the irrigation management. Land use survey data are challenged by irrigation managers on the pretext that farmers under-report canal irrigated area to avoid paying water charges. Remote sensing maps can help assess total irrigated area in a command but not by source. The difficulty of measuring the performance of public irrigation management poses a formidable obstacle in the challenge of performance improvement.

To understand the persistently poor performance of major and medium projects, the Government of India commissioned the four Indian Institutes of Management (IIMs) to undertake an in-depth study of the issues involved. The question they posed was: why is the gap between irrigation potential created and

Table 6.3 Various Estimates of Area Irrigated by Canals and Wells in India, *C.* 2000

		Data for year	*Major and Medium Schemes*	*Groundwater*	*Other sources*
1	Minor Irrigation Census, October 2005, Net area irrigated†	2000–1	10.23 m ha	30.5 m ha	5.71 m ha
2	NSSO 59th Round‡	January–December 2003			
2a	Percentage of net area sown in kharif irrigated by: Estimated kharif area irrigated by:#		7.75 per cent 8.37 m ha	28.95 per cent 31.3 m ha	5.55 per cent 5.99 m ha
2b	Percentage of net area sown in rabi irrigated by: Estimated rabi area irrigated by: Estimated gross area irrigated by:		7.68 per cent 7.83 m ha 16.2 m ha	42.86 per cent 43.7 m ha 75 m ha	5.79 5.91 m ha 11.9 m ha
3	Ministry of Agriculture, GoINet area irrigated by different sources	2001–2	15.9 m ha	35.04 m ha	7.59 m ha
4	CWC	2001–2	31.3 m ha	35 m ha	
5	IWMI global irrigated area map using remote sensing data (gross area irrigated)*	2004–5	55 m haΨ	91 m haΩ	

Notes: † From the Abstract of information from GoI (2005), Village Schedule, Table 6.1, p. 321.
‡ GoI (2005: Table 3.4.1). This survey covered 51,770 farming households from 6638 villages around India.
# Kharif cropped area in 2002–3 was 108 million ha and rabi cropped area was 102 million ha. See (NSSO 2005) http://www.mospi.gov.in/press_note_nsso_31august06.htm
* Thenkabail et al. (2006).
Ψ Conjunctive use areas in command of major and medium irrigation systems.
Ω Gross area irrigated by groundwater structures, small tanks, and other sources outside the command areas of major and medium irrigation systems.

the area actually irrigated by public systems widening?[4] Regrettably, the question itself was trivial and produced a trivial answer. The question is trivial because the 'irrigation potential' is defined simply as the 'presumed' volume of water expected in the reservoir divided by a 'presumed' irrigation delta required for a 'presumed' cropping pattern, totally overlooking the ground reality of Indian canal irrigation. In no Indian irrigation system do the real values of these variables approach their presumed values which in any case are arguably the numbers chosen to justify project investment rather than honestly considered estimates. The gap between potential created and area irrigated is thus a good indicator of poor planning of irrigation projects rather than of canal irrigation performance. Researchers really interested in the performance of public irrigation projects ask different questions and, therefore, get different, often more insightful answers.

From the viewpoint of irrigators, the performance of an irrigation system is judged by the level of water control it offers to farmers within the design command (Boyce 1988). Freeman et al. (1989) define water control as the capacity to apply the proper quantity and quality of water at the optimum time to the crop root zone to meet crop consumptive needs and soil leaching requirements. The performance gap between the level of water control that command area farmers expect and what they actually receive is the sum of three component gaps:

- Gap I: Gap between the area (and farmers) designed to be served by gravity irrigation and the area (and farmers) actually served after the system begins operation;
- Gap II: Gap between the level of 'water control' promised at the planning stage and the level of 'water control' actually delivered after the beginning of the operation;
- Gap III: Gap between the level of 'water control' demanded by farmers at the present point in time and the level of 'water control' actually offered by the system.

Gap I often arises because irrigation systems are over-designed to make them appear more viable and beneficial than they can actually become. Irrigation delta assumed is lower than realistic so that a larger design command can be shown. Once the system is commissioned, the gap tends to expand because of the acts of omission and commission that subvert the objectives of system management. Acts of commission include water thefts, vandalism, violation of water distribution norms, and unauthorized diversion or lifting of water from canals by head-reach farmers. Acts of omission include farmers' own failure to cooperate in maintenance and repair, to pay irrigation charges, and so forth (Burt and Styles 1999; Pradhan 1989: 18; Oorthuizen 2003: 207).

Gap II generally arises because of inept system management as well as physical deterioration of the system and reengineering by farmers (Oorthuizen 2003). Also important are operating rules for reservoir and main system management. In multi-purpose projects, the hydro-electric plants often determine the protocol and schedule for releasing water from reservoirs without much regard for the irrigators' needs.

Gap III arises from the changing pattern of irrigation demand, mostly due to diversification of farming towards high value crops. Irrigation systems designed for rice/wheat rotations or for extensive irrigation can meet only a small fraction of the water control needs that diversified farming systems require, which impose a different irrigation schedule. Depending only on public irrigation systems would thus drastically reduce the opportunity set of farmers who then turn to groundwater irrigation to provide them the high level of water control they need for their diversified cropping patterns.

For long, poor performance was blamed on the physical deterioration of systems and poor maintenance, and numerous programmes were launched to 'rehabilitate' surface irrigation systems. But as Boyce (1988: A-9) pointed out, 'The social difficulties of achieving joint water use among many irrigators may exceed the technical difficulties of constructing large-scale systems'.

[4] Different departments measure irrigation potential created and utilized differently. The Irrigation Department estimates the ayacut by the volume of water released and an assumed duty of water. The Revenue Department estimates area irrigated based on the water cess actually collected. It also uses the previous records of localization orders issued earlier. The Agriculture Department goes by the area in which crops are raised under irrigation. All these estimates differ widely and no attempt is made for reconciliation at any stage.

As a result, evaluations repeatedly found that physical rehabilitation was not a silver bullet. Typically, a visible performance jump following the immediate physical rehabilitation enlarged the command area and improved fee collection, water flowed unimpeded to the tail-end, and users expressed satisfaction. A few years later, water fee collection would languish, and anarchy levels rise. Maintenance would be deferred; degradation of the system would begin slowly and then accelerate, causing head–tail imbalance and prompting another round of rehabilitation. In South Indian tanks, the cycle has been so short that new rehabilitation plans are afoot even before the last plan is fully implemented. Mohanty (2005) calls this the *build–neglect–rebuild* syndrome. Recent thinking about improving performance of surface systems therefore favours modernization, defined as the 'process of technical and managerial upgrading … of irrigation schemes combined with institutional reforms, with the objective to improve resource utilization … and water delivery service to farms' (Renault 1998: 8). Involving farmers in irrigation management through participatory irrigation management (PIM) is a key component of modernization. But can PIM help to close performance gaps I, II, and III?

Improving Public Irrigation Performance: Can PIM Do It?

Unfortunately, PIM—and its sibling, irrigation management transfer (IMT)—have proved ineffective in revitalizing canal and tank irrigation not only in India but in much of Asia (Mukherji et al. 2009). The idea of PIM goes back to traditional Farmer Managed Irrigation Systems (FMIS), in whose case a distinct 'irrigation culture' passed over generations of irrigation communities. However, the logic of transforming traditional 'irrigation communities' into PIM through WUAs in a government-run irrigation system has itself been questioned (Hunt 1989; Narain 2004). Coward (1983) argues that:

> The basic point is to understand that the fundamental processes of investment now being made by the State [in large irrigation projects] fail to create property relationships among the water users, and thus are unable to support the creation of a social basis for action among local people.

What is extraordinary about PIM (and IMT, which is as yet untried in South Asia) is the way it has continued to hold on the irrigation management discourse despite virtually no evidence of its having succeeded anywhere in the developing world except on an experimental basis, and only with facilitation of un-replicable quality and scale. That system managers want farmers to manage irrigation canals is not new; the British tried hard in late nineteenth century to get farmers from the Indo-Gangetic basin to participate in irrigation management but without much success, except in *warabandi* in the Indus canals (Whitcombe 2005). Since Independence, farmers' organizations for irrigation management have been regularly tried, with uniformly disappointing results. In the early 1960s, Uttar Pradesh tried *Sinchai Samitis* (irrigation committees) on irrigation tanks and reservoirs; later, Madhya Pradesh tried it on thousands of its minor irrigation tanks. Other states have been struggling to make *Pani Panchayats* (water assemblies) work. However, the Sinchai Samitis of Madhya Pradesh and Uttar Pradesh have disappeared without trace, and so have Pani Panchayats in Gujarat and elsewhere. Gujarat introduced its Joint Irrigation Management Programme in 1983, but the 17 irrigation cooperatives lost money and were disbanded. In 1991, it made another attempt, this time with assistance from local non-governmental organizations (NGOs), and 144 irrigation cooperatives were formed to cover 45,000 ha of irrigated area (Shukla 2004). However, these cooperatives never functioned, and it is difficult to see precisely how PIM areas were better off than other command areas.

In sum, it is a rare circumstance in which WUAs have improved the performance of public irrigation systems on a large scale in South Asia. And that too only when a mid-sized NGO invests years of effort and resources in organizing WUAs and using means to reduce transaction costs that farmers on their own would normally not possess. Some of the best known examples of successful PIM/IMT on large government-run surface irrigation systems in India are Ozar on Waghad project in Nashik, Maharashtra, Dharoi in North Gujarat, Pingot and a few more medium schemes in Bharuch district. The success of farmer management in all these—and its beneficial impact—is undisputed. In each of these, however, there was a level of investment of motivation, skill, time, effort, and money which is unlikely to be replicated on a large scale. In catalyzing Ozar cooperatives, Bapu Upadhye, Bharat Kawale, two popular local leaders and their NGO Samaj Pragati Kendra, and senior researchers of SOPPEKOM, a local research group, invested years of effort to make PIM work (Paranjapye et al. 2003). In Gujarat, the Aga Khan Rural Support Programme and Development Support Centre invested at least 30 professional field staff for over 10–15 years to organize say 20,000–30,000 flow irrigators into functional WUAs. However, no government agency in India has the quality and scale of human and other resources, nay the motivation levels, needed to implement an institutional intervention that can sustainably raise the productivity of the 35–40 million ha of flow irrigated area, over say 15 years.

Nevertheless, the fascination with the idea continues as governments and donors seek to rejuvenate irrigation systems with the magic wand of PIM. And the recent fad is to do it with a 'big bang'. Orissa recently passed a law that transferred all its minor irrigation systems to instantly created Pani Panchayats. And Andhra Pradesh created more than 10,000 WUAs by a stroke of its chief minister's pen. The Andhra Pradesh reform is lauded by some observers as a great example, even though dozens of institutional big bangs of this genre have quietly ended as whimpers. And if the 250,000 ha decline in surface irrigated area in Andhra Pradesh between the 1993–4 and 2000–1 minor irrigation censuses is any indication, Andhra Pradesh's reforms are already a whimper. The World Bank loan spent, field researchers in Andhra Pradesh too are beginning to wonder precisely what the WUAs are doing better than before (Jairath 2001; Reddy 2003; Madhav 2007). Chapter 9 of this *Report* discusses the effectiveness of WUAs in selected states in India.

Indeed, a primary purpose of the command area development agencies (CADAs) formed by the Government of India in the early 1980s was to involve farmers' organizations in the management of irrigation projects. However, there is no trace of CADAs or their 'beneficiary farmers' associations' (BFAs). In Kerala, thousands of such organizations were formed in 1986. An assessment by Joseph (2001) in the late 1990s suggested that even in Kerala, with strong traditions of local governance, high education, and high levels of participation in public affairs, the beneficiary farmers' associations were a damp squib. Some random excerpts from Joseph (2001) based on his study of the Malampuzha Project:

> It is the CADA officials who took the initiative in their formation and not the farmer groups. In most cases, membership fee of Rs 5 was not paid by the farmers concerned; payment was made on their behalf by prospective office bearers, or the potential contractors of field channel lining or the large farmers in the *ayacut* … 86 per cent (of the BFAs) were formed in these two years (1986 and 1987) … for making possible the utilization of funds.… Only 57 meetings were held by the 8 Canal Committees during a span of 10 years … 43 of them were held without quorum and 35 with zero attendance of non-official members … The level of knowledge … about Canal Committees … and there structure and functions is very low.…

The action of PIM is driven by the idea that WUAs can manage irrigation systems better than remote bureaucracies and that they would be better at controlling anarchy, improving water service, collecting fees, and maintaining the system. This would raise water and land productivity and improve the economic conditions of the farmers. Democratic governance aside, PIM programmes have belied many of the lesser expectations even where they are widely considered successful, as in Turkey, Mexico (Kloezen 2002; Rap 2004), and the Philippines (Oorthuizen 2003). As a result, expectations have been increasingly moderated and participatory management is now considered successful even if it just 'saves the government money, improves cost effectiveness of operation and maintenance while improving, or at least not weakening, the productivity of irrigated agriculture' (Vermillion 1996: 153). The discussion, in recent times, has been more about shifting responsibility away from governments than about improving the lot of farmers—the original goal towards which most of the public irrigation investment has been directed over the past 50 years.

The lesson learnt is that the benefits of rehabilitation and upgradation are transitory without the capacity to control anarchy, and when it comes to controlling anarchy, the idea of gravity flow irrigation itself is up against some hard questions in India.

Socio-technical Pre-conditions for Canal Irrigation

Can India's publicly managed canal irrigation systems reproduce some of the productivity, socio-economic, and financial outcomes in the twenty-first century that they demonstrated at the end of the nineteenth? A likely answer is 'no' because the socio-technical conditions in which canal irrigation can thrive were all present then and are all absent now. Table 6.4 summarizes a broad-brush selection of the socio-technical conditions prevalent during pre-colonial, colonial, and post-colonial eras in many Asian countries including Mughal and British India. Our hypothesis is that particular forms of irrigation organization that we find in these eras were in sync with the socio-technical fundamentals of those times. Irrigation communities thrived during pre-colonial times when: (a) there was no alternative to sustained collective action in developing irrigation; (b) strong local authority structures, such as zamindars

Table 6.4 Socio-technical Context of Surface Irrigation in Different Eras

	Pre-Colonial (Adaptive Irrigation)	*Colonial (Constructive Imperialism)*	*Post-Colonial (Atomistic Irrigation)*
Unit of irrigation organization	Irrigation Community	Centrally managed irrigation system	Individual farmer
Nature of the state	Strong local authority; state and people lived off the land; forced labour; maximizing land revenue chief motive for irrigation investments.	Strong local authority; land taxes key source of state income; forced labour; maximizing land revenue and export to home-markets chief motive for irrigation investments; state used irrigation for exportable crops.	Weak state and weaker local authority; land taxes insignificant; poverty reduction, food security, and donor funding key motives for irrigation investments; forced labour impossible; electoral politics interfere with orderly management.
Nature of Agrarian society	No private property in land. Subsistence farming, high taxes, and poor access to capital and market key constraints to growth; escape from farming difficult; most command area farmers grew rice.	No property rights in land. Subsistence farming and high taxes; access to capital and market key constraints to growth; escape from farming difficult; tenurial insecurity; most command area farmers grew uniform crops, majorly rice.	Ownership or secure land use rights for farmers; subsistence plus high value crops for markets; growing opportunities for off-farm livelihoods; intensive diversification of land use; command areas witness a wide variety of crops grown, with different irrigation scheduling requirements.
Demographics	abundant land going a begging for cultivation; irrigable land used by feudal lords to attract tenants	abundant land going a begging for cultivation; irrigable land used by feudal lords to attract tenants	Population explosion after 1950 and slow pace of industrialization promoted ghettoization of agriculture in South and South-east Asia and China.
State of irrigation technology	Lifting of water as well as its transport highly labour intensive and costly;*	Lifting of water as well as its transport highly labour intensive and costly;	Small mechanical pumps, cheap boring rigs, and low cost rubber/PVC pipes drastically reduce cost and difficulty of lifting and transporting water from surface and groundwater.

Source: Shah (2009).

Note: * Assuming that a pair of bullocks pulling a 100 litre leather bucket do 100 turns a day for say 100 days per year, lifting 5 km^3 of water from wells would require 10 million bullocks working on wells. This work is done today in the Ganga basin by around 300,000 five-horse power (hp) diesel pumps doing 8 hours/day for 100 days. In Gorakhpur, James Buchanan estimated that 10 men could water from a ditch 3000 to 5000 square feet/day using swing-baskets. A 1 hp pump can do this work now in less than an hour. Besides the drudgery, the financial cost was an issue, too. The cost figures for those days given by the Agriculture Commission were Rs 7–20 per ha for canal irrigation and Rs 54 per ha from a well. 'In view of such a large difference in cost, it was not surprising that wells were superseded by canals as the source of water supply in areas supplied by canals' (Randhawa 1983: 291).

in Mughal India, promoted—even coerced—collective action to enhance land revenue through irrigation; (c) exit from farming was difficult; and (d) irrigating with wells, where possible, was highly laborious, costly, and time-consuming.

Similarly, large-scale irrigation systems during colonial times kept the three performance gaps (discussed above) under control because: (a) land revenue was the chief source of income for an authoritarian government, and enhancing it was the chief motive behind irrigation investments;[5] as a result, irrigation managers had a strong stake in ensuring that the mainsystems were well managed and maintained; (b) the state had a deep agrarian presence and used its authority to extract 'irrigation surplus' and impose discipline in irrigation commands; (c) the farmers in canal commands had no practical alternatives to either subsistence farming livelihoods or to gravity flow irrigation since well irrigation remained costly and laborious; and (d) population pressure on farm lands was nowhere as severe as found today. These socio-technical conditions created an 'institutional lock-in' that ensured that public irrigation systems performed in terms of criteria relevant to their managers at those times.

Post-colonial India is confronted with a wholly new array of socio-technical conditions in which neither irrigation communities nor disciplined command areas are able to thrive. The Welfare State's revenue interests in agriculture are minimal; the prime motive for irrigation investments is food security and poverty reduction, and not maximizing government income. Governments have neither the presence and authority nor the will to collect even minimal irrigation fees that are needed to maintain the systems.[6] Also, agrarian economies are in the throes of massive change. Farmers can—and do—exit agriculture with greater ease than ever before. Growing population pressure has made small-holder farming unviable except when they can intensify land use and diversify into high-value crops for the growing urban and export markets. In any case, to sustain surface irrigation seems to require an 'optimal' population density; at very low population density, it is not worthwhile; but beyond a threshold, land becomes so valuable that using it for water storage and transport comes under severe pressure (von Oppen and Rao 1987: 36).

Finally, gravity flow irrigation systems are hit by the mass-availability of small pumps, pipes, and boring technologies that have made the 'irrigation community' redundant; these have also made the irrigator impervious to the progressive widening of the three performance gaps, and reduced his/her stake in their performance. But for the rise of pump irrigation, canal irrigators would have protested non-performance by voice; now they have the easier option of exit (Hirschman 1965).

Adapting system design and management to the phenomenal expansion in pump irrigation is arguably, by far, the most formidable challenge to government canal irrigation systems and their managers. One way to adapt, many argue, is by modernizing Indian irrigation systems to make them more demand-oriented, as in Australia or the commercial farming sector in South Africa where they cater to a small number of large users and provide each with a level of water control that the Indian small farmer seeks from his own borehole and pump. But this may be a vain hope. Moreover, such modernization will work only to the extent that it addresses the rapidly changing socio-technical fundamentals of the canal irrigation context of India. Rather than improving canal irrigation performance by 'reforms'—institutional reform (like PIM/IMT), bureaucratic reform, reform of main system management (Wade and Chambers 1980)—India may be better off 'morphing' its canal systems to fit the changing socio-technical context of its agrarian economy in transition.

[5] Land revenue constituted 60 per cent of the East India Company's total income in the 1840s (Banerjee and Iyer 2002); though its share declined somewhat, it stayed at around 50 per cent throughout the nineteenth century.

[6] As Wallach says of the Nagarjunsagar project: 'The problem is partly engineering one…; more fundamentally, however, the problem is political, for the government is unable to prevent farmers at the upper or head ends … from taking so much water that the tail ends run dry … Little has been published on the subject, perhaps because India has put so much money, professional pride, and dreams of prosperity invested in the projects. Yet, many irrigation engineers in India will admit privately that the waste of development finds is staggering', available at http://ags.ou.edu/~bwallach/documents/Krishna% 20Basin.pdf last accessed on 30 October 2009.

Future of Canal Irrigation: Reform or Morph

What is the path that canal irrigation will—or can—follow in the future, over say a 25-year time horizon? Many scenarios are possible; but four are explored below.

Business-As-Usual Scenario

This is the most likely scenario and assumes that construction and management of canal irrigation projects will continue in a 'business-as-usual' mode. This will imply, among other things, that: (i) governments at the central and state levels will continue to construct large public irrigation projects despite their poor performance track record and without understanding how to improve their performance; (ii) similarly, multi-lateral lenders will continue to find new irrigation projects as well as rehabilitation/modernization projects that are attractive for making large loans that governments are happy to receive regardless of the past experience with the performance of such loans and their future prospects; (iii) poor performance of irrigation systems will continue to be blamed on the anarchy below the outlet; and despite lack of evidence of large-scale success, PIM/IMT will continue to be peddled as blanket solutions for improving system performance; (iv) since the best sites have already been used up, new projects will be increasingly costly and unviable, like the massive lift irrigation projects under construction on the Godavari River in Andhra Pradesh whose energy cost of pumping the water itself is estimated at Rs 17500/ha; (v) to justify unviable projects, planners will continue to overestimate the design command area[7] and assume unrealistic irrigation duty; once commissioned, the head-reach farmers will make a habit of irrigating water-intensive crops ensuring that the actual area commanded is a half or a third of the original plan; (vi) political leaders will continue to score electoral brownie points in initiating and constructing grandiose projects, without paying much attention to the stringent institutional and management requirements to achieve the performance goals of these systems; irrigation projects will also be attractive to politicians for the opportunities these provide in favouring supporters with construction contracts; (vii) irrigation departments will continue to remain construction-oriented with engineers having little interest or incentive or capacity in efficient management of systems so that they achieve their full performance potential; (viii) even if bureaucracies were motivated and capacitated, canal irrigation performance is difficult to measure and monitor when land revenue and water fee collection have been trivialized; (ix) in some states, irrigation departments will continue to stagnate or even shrink in size; states like Gujarat have not hired an irrigation engineer in 20 years, and by 2015, all engineers are expected to have retired; this will leave little organization to manage these large irrigation capital assets; (x) where irrigation departments are growing, with rising government salaries and stagnant irrigation fee collection, establishment costs, as share of working expenses, will increase with little left to repair and maintain the systems; (xi) in overall terms, the low-level equilibrium in which public irrigation in India is comfortably ensconced today will continue; governments will keep throwing good money after bad; multi-lateral lenders will keep financing unviable rehabilitation projects; and overall, more and more money invested will keep giving India less and less canal irrigation as has happened since 1991; (xii) the key socio-economic benefits of such projects—often more than gravity fed irrigated areas—will be in terms of recharging the aquifers in the areas where they can reach water by gravity flow and feeding urban water supply schemes.

Expanding the Area under Conjunctive Management of Surface and Groundwater

The simplest step that canal irrigation management in India can take to significantly enhance its impact is to maximize areas under conjunctive use of ground and surface water. Presently, this is not happening because India's irrigation systems irrigate only a fraction of the area they were designed to and they can with tighter management of the main system. India's canal systems

[7] For example, the Sardar Sarovar Project (SSP) is planned to irrigate 1.8 million ha on the assumption that the project will ration canal water at a delta of 53 cm/year. If we take the total water circulating in Indian canal systems at 300 BCM and divide it by the 17 m ha that this irrigates, the storage per net ha irrigated comes to 17,640 m^3. As a project representative of Indian canal irrigation sector, then SSP cannot command more than 0.55 million ha.

are designed to mobilize and move around some 300 billion cubic metre (BCM) of water[8] in a normal year. According to the CWC, these irrigate some 30 million out of a total of 37 million ha that can be potentially irrigated. According to the land-use survey data as well as the minor irrigation census data, however, only about 14–15 million ha are irrigated by major and medium public irrigation projects. According to the CWC, the volume of storage needed to irrigate a hectare is around 10,000 m^3/ha. The Land Use Survey (LUS) data suggest that the volume of water storage often increases to 20,000 m^3/ha, a good deal of which either creates water-logging or evaporates without producing any benefit. In comparison, 230 BCM of groundwater storage gives India a gross irrigated area of 35.2 m ha. Thus, the groundwater storage that India needs to support an irrigated ha is between 4300 to 6600 m^3/ha, much lower than that required for surface irrigation.

A potentially gigantic opportunity for unlocking value out of India's canal systems is by spreading their waters on much larger areas to expand the areas under conjunctive management of surface and groundwater. Around the world, a key problem in achieving such conjunctive use is the reluctance of command area farmers to invest in groundwater irrigation structures. In Pakistan during the 1950s, the World Bank had to invest in the Salinity Control and Reclamation Programme (SCARP) tube well programme to stimulate conjunctive use. In India, this is no longer a problem since irrigation wells dot the entire landscape of the country. Many Indian systems were designed as extensive (or protective) irrigation systems to support irrigated dry crops that can be matured with relatively low delta. However, due to poor system management and political intransigence, most systems have degenerated into intensive irrigation systems where a fraction of the design command uses 10,000–15,000 m^3 of water/ha to grow water-intensive crops.

It is possible to argue that canal systems can be transformed into extensive systems as they were planned, without much investment simply by improving the management of the main system. Most rehabilitation and modernization projects aimed at doing precisely this. However, these projects ended up spending huge sums on construction and little on management improvement and capacity building. Improving the management of main systems holds the key to unlocking value in India's public irrigation (Wade and Chambers 1980). Doing this, however, requires reform and revitalization of irrigation bureaucracies more than PIM/IMT and spending billions on reconstruction.

Irrigation Agencies Reinvent Themselves

Irrigation bureaucracies can reinvent themselves provided there exist certain prerequisites in their internal and external task environment.

Unbundling of the monolithic irrigation bureaucracy is one possible way (a successful example of improvement in performance through unbundling exists in the electricity sector in some states in India, which has some parallels to the irrigation sector). There are no easy answers to this question. The idea of unbundling has already been tried in Gujarat's Sardar Sarovar Narmada Nigam Limited (SSNNL), a special purpose vehicle created outside the Irrigation Department to construct and manage the Sardar Sarovar Project. However, there seems little evidence to suggest that SSNNL has done better than the Irrigation Department as either a 'profit centre' or a 'responsibility centre'. A pre-condition for any management turnaround is reliable information about organizational performance. In canal irrigation, this precondition is not satisfied today; even on basic variables—such as, the area wetted by canals in a system—different government sources provide vastly different numbers. Because irrigation charges are hardly collected, even water fee realization is a poor indicator of area irrigated. Finally, unlike during colonial times when irrigation fees commanded one-third crop share, canal irrigation is inherently unviable as a business today. Despite these issues, the performance of irrigation agencies would improve if: (i) a reliable and transparent Management Information System were established to monitor the performance of each irrigation system; (ii) the monolithic department was unbundled into independent management units for each system with operational autonomy, freedom from political

[8] This includes around 215 BCM of reservoir storage, and around 80 BCM in run-off the river system plus thousands of large irrigation tanks and *ahar-pyne* systems.

influences, agreed management goals, and performance-based reward system; and (iii) a transfer pricing scheme were evolved to translate system performance into a performance management system for the agency.

Morphing into Hybrid Systems with Public Private Partnerships

A third scenario of where Indian canal irrigation might go in the future is for the irrigation agencies to enlist the 'water scavenging anarchy' as a partner and leverage it to enhance their reach and performance. A good example is provided by developments in the upper-Krishna basin in Maharashtra. In 1976, the Bachhawat Award allocated 560 TMC of water to Maharashtra which the state had to develop by the year 2000. Maharashtra was not in a position to build reservoirs and canal networks needed to use this water and by 1996, it had constructed only 385 TMC of storage and little had been done by way of establishing a canal network in the Krishna basin. Therefore, the government first began allowing farmers to lift water from Krishna and its tributaries. This encouraged small-scale private lift schemes most of which could not convey water to longer than 1–1.5 km distance. In 1972, only 200 private and co-operative lift schemes were operating in Maharashtra. As pressure to utilize the water mounted, the government adopted a far more proactive posture towards lift irrigation schemes. It introduced a capital cost subsidy for irrigation cooperatives and also facilitated bank finance from nationalized and cooperative banks. Most importantly, the Irrigation Department (ID) constructed a series of Kolhapur Type (KT) weirs across many tributaries of Krishna to use them as storages for lift irrigation schemes. Each scheme has to be approved by the ID, whereupon it qualifies for an electricity connection and bank finance. Each scheme also has to pay irrigation fees to the ID for the actual area irrigated; it also has to pay electricity charges to the State Electricity Board at prevailing rates for agricultural use. Between December and June each year, the ID implements a fortnightly schedule of water releases to fill up the dykes, starting with the last dyke first. This ensures that lift schemes have access to reliable water supply during the irrigation season.

A good example of the kind of partnership that Maharashtra's policies have spontaneously promoted between the ID and irrigation cooperatives is the Radhanagari project (constructed by Shahuji Maharaj in 1916) that serves 91 villages in Kolhapur district (studied by Choudhury and Kher 2006; Padhiari 2006; and Chandra and Sudhir 2010). The dam never had any canals; water is released from the dam into Bhogavati River on which the ID has constructed a series of KT weirs. The ID has three roles: (i) to approve proposals for new schemes; (ii) to release water into Bhogavati river every 15 days to fill up all the KT weirs; and (iii) to collect irrigation fees from all lift schemes based on crop and area irrigated. Water lifting, conveyance, and distribution are all done by some 500 ISPs in private and cooperative sectors.

Radhanagari's performance over the past two decades has been very good compared to surface irrigation systems anywhere in India. Against a design command of 26,560 ha, the average area irrigated by ISPs during 2001–6 was 30,341 ha. The ID managed to collect only 58 per cent of the irrigation charges that were due; however, against the annual O&M cost of Rs 79 lakh, irrigation charges collected in 2005–6 were Rs 179 lakh. In terms of the area irrigated as well as irrigation charges recovered, tail-end areas were found no worse off compared to head; the practice of filling up KT weirs last to first seems to address the head–tail inequity. An informal survey suggested that the number of irrigations the project provides is 80 to 90 per cent of the number needed and that over 80 per cent of the farmers interviewed were happy with irrigation provided by the ISPs (Choudhury and Kher 2006). In terms of offering irrigation-on-demand, Radhanagari comes close to tube well irrigation. Choudhury and Kher (2006) interviewed eight private and nine cooperative ISPs that irrigate a little over 1000 ha in Radhanagari project. These have together invested nearly Rs 22 crore in systems that include 2280 hp of pumps and 41 km of buried pipe network and employ 92 staff to manage water. Typically, every system has a rising main—sometimes, multi-stage—to a chamber from where water is conveyed by buried pipes to fields. These ISPs thus invested Rs 2.2 lakh/ha in the system, use 2.3 hp/ha of power load, employ a water manager for every 12 ha irrigated and collect an irrigation charge that is high enough to pay off debt, pay electricity charges to the Electricity Board, irrigation charges to the ID, and salary to employees, and save enough for prompt repair and maintenance.

Radhanagari is not the only exception. According to the GoI's Minor Irrigation Census III, in 2000–1, Maharashtra had some 100,000 such schemes in operation for lifting and piped distribution of surface water, mostly in the Upper Krishna basin. Over 20,000 of these were owned and operated by farmer groups and Co-operatives. These lifted water from rivers and streams and transported it mostly by buried pipelines to areas up-to 30 km from the source. Remarkably, none of these was operated by a government agency. Over 90 per cent of Maharashtra's lift schemes were constructed by farmers from their own funds and bank finance, with the present value of aggregate investment of around Rs 5000 crore. Over 90 per cent schemes used electric pumps to lift water and 70 per cent had buried pipeline networks for water distribution. Total horse power of pumps installed in these schemes was around 590,000, equivalent to 440 MW, even though all the schemes involved a sizeable lift ranging from 20 meters to 185 meters. These irrigated a gross area of some 350,000 ha (including sugar-cane area of over 100,000 ha). Maharashtra's lift irrigation schemes employed over 100,000 workers as *pankhyas* (water managers), if we count the fact that the 80,000 families operating private lift schemes had at least one family member each devoted fulltime to work on the scheme operation.

Where-ever canals offer reliable water supply, private investors have invested in turning water into an 'irrigation service' that mimics on-demand groundwater irrigation. A sample of the many ways in which farmers have modified and adapted canal systems to their needs is listed in Table 6.5. If we were to learn from this experience, a variety of management models emerge in which the irrigation agency has a new, more limited role of delivering bulk water at pre-designated points in the command area and a variety of private arrangements are allowed to provide an 'irrigation service'. Regardless of whether governments support these or not, they are emerging and playing a major role in water distribution in many systems. This is the closest that canal irrigation can come to mimicking the flexible, on-demand groundwater irrigation.

At present, such private pump and pipe systems on canals are considered illegal, However, these systems can also be integrated with canal systems as hybrid systems in which the agency promises to deliver bulk-water at, say, a minor-level along a predetermined schedule and licensed ISPs, paying a volumetric water charge assume the responsibility of distributing water to their farmer-customers through a buried pipe network. Such hybrid systems involving piped distribution have several advantages over the conventional gravity flow systems: (i) private partners take up a large part of the capital investment of a canal system by constructing the distribution system; (ii) a buried pipe distribution system faces much less 'right-of-the-way' problems that canals face; (iii) piped distribution saves land used up for sub-minors and field-channels; (iv) it minimizes water-logging that is rampant in canal-based distribution systems; (v) piped distribution is considered too costly in comparison to earthen canals but is actually quite cost-effective if the land required for canals is valued at market price; (vi) a canal network is a vast evaporation pan especially at the level of the distribution system where surface area to depth ratio of channels is low; piped distribution can save some of this non-beneficial evaporation loss; (vii) piped water delivery from canals mimics tube well irrigation and raises productivity of irrigation water applied even more so because users pay a high price for the irrigation service; (viii) done right, piped distribution can help spread canal water over a much larger area than surface canals can; (ix) it can put into a place a regime of conjunctive use of ground and surface water that may tackle the acute problem of groundwater depletion; (x) while pipelining is more energy-intensive compared to gravity canals, if managed well, it can significantly improve the overall farm energy balance of the country by spreading surface water on a larger area, reducing the need for groundwater pumping, by integrating micro-irrigation technologies, and enhancing recharge from canal waters thereby reducing the energy used for groundwater pumping; (xi) while farmer participation in canal irrigation management has been hard to come by, under such a hybrid PPP model, farmer participation in irrigation management begins at the construction stage itself.

If the Maharashtra experience is any guide, inviting farmers to participate in creating such hybrid systems is not difficult. To promote farmer investments in piped distribution in a planned and systematic manner, all that the agencies need to do is the following: (i) not only recognize and legalize but also register and incentivize lifting of water from canal systems and its

TABLE 6.5 Farmer Modifications and Adaptations of Canal Systems to Serve their Needs

#	*System modification and adaptation*	*Examples*	*How widespread is this in India?*	*Extent of farmer enterprise and investment*	*Precondition for farmer enterprise and investment*	*Presence of Irrigation Service institutions*
1	Classical Canal Irrigation: The system operates as designed; wells are driven out by gravity flow irrigation	Mahi command in early 1970s;[a] Bhakra command in the 1950s	Not at all	Negative		Nil
2	Main system delivers water in farm ponds (diggis) fortnightly	Indira Gandhi canal, Rajasthan[b]	Not very	Low; individual farm ponds	Regular water supply to	Nil
3	Main system delivers water in village ponds as intermediate storages; farmers irrigate by gravity or lift	Sardar Sarovar; System tanks in South India	Some	Low; individual	Tanks replenished regularly	Some presence of Irrigation Service Markets (ISMs)
4	Main system delivers water into canals; farmers/groups lift and irrigate	Mahi system;[c] Upper Krishna;[d] Sardar Sarovar command[e]	Very widespread throughout India	Substantial; private and cooperative	Perennial or full season canals at run at FSL	High to very high presence of ISMs
5	Main system delivers water to a village contractor on volumetric basis and he allocates water to farmers and collects water fees	Several systems in China[f]	This model is spreading in China	Substantial, private	Perennial or full season canals at run at FSL	High presence of ISMs
6	Main system recharges the aquifers in the command; much irrigation surplus results from tube well irrigation	Bhakra;[g] Mahi;[h] Upper Krishna basin;[i] Tamil Nadu[j]	Very, very widespread	Substantial, mostly private;	None; alluvial aquifers, unlined canals help	High to very high presence of ISMs
7	Irrigation tanks support well irrigation in their command	Tamil Nadu;[k] AP;[l] Karnataka; Eastern Rajasthan[m]	Very, very widespread	Substantial, mostly private	None	Some presence of ISMs
8	Irrigation tanks converted into percolation tanks	Much of Tamil Nadu;[n] Rayalaseema[o] in Andhra Pradesh	Not very, but gaining	Substantial, mostly private	Consensus among tank irrigators	Some, to high presence of ISMs

Notes: [a]Shah (1993); [b]Amarasinghe et al. (2008); [c]Choudhury and Shah (2005); [d]Lohar et al. (2006); Birari et al. (2003); Choudhury and Kher (2006); Padhiari (2006); [e] Talati and Shah (2004); Talati and Pandya (2007); and Singhal and Patwari (2009); [f] Shah et al. (2004); Wang et al. (2003); [g]Dharmadhikari (2005); *Down to Earth* (2005); [h]Shah (1993); Shah (2009); and Kolavalli (1986); [i]Venot (2008); Biggs et al. (2007); [j] Sivasubramaniyan (2008); [k]Palanisami and Easter (1991); Palanisami and Balasubramanian (1998); [l]Rao (2003); [m] Shah and Raju (2001); [n]Palanisami (1995, 2005); [o]Rao (2003).

piped distribution; (ii) make firm commitments—during the irrigation season each year—of weekly water deliveries in each distributary/minor according to a strict schedule, as in the Radhanagari system described above; (iii) existing tube well owners should be encouraged to convert their electricity connections to canal lift; (iv) electricity connections should be provided to approved piped distribution schemes planned by farmers, cooperatives, and producer companies; (v) institutional financial agencies should be involved in providing finance to support farmer cooperatives for their investments in pumps and pipeline systems; (vi) government should provide 25 per cent subsidy on capital costs of approved projects; (vii) each pipeline system should be registered with the Irrigation Department and be required to pay irrigation fee for all the land irrigated with canal water; (viii) the idea of 'irrigation command' should be modified to include any farming community that is willing to invest in piped distribution and pay a volumetric water charge.

Conclusion

According to Kurt Levin's force-field analysis, India's public irrigation management will begin to change for the better when drivers of change will outweigh the forces that restrain change. For the moment, the latter far outweigh the former and will make 'Business-as-Usual' (outlined above) the most likely option. Indeed, one can find hardly any notable 'driver' that would create pressure for a major change programme in the public irrigation sector. Governments and donors have been throwing good money after bad; and they will keep doing so regardless of what the past investments delivered or failed to deliver. If a battery of 'change drivers' were to be created, the work would need to begin by creating a credible information and monitoring system about how public irrigation systems are performing against their original designs, their current objectives, and vis-à-vis each other. In business, measuring performance is generally considered essential to managing it. This seems nowhere more true than in the public irrigation business in India today.

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